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he Concept of the Minimal Information Required for Effective Mobility and Suggestions for Future Non-Visual Displays

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Paper presented at Airlie House, Warrenton, Virgina, June 21/22, at a Conference organised by the Sensory Aids Subcommittee of the National Academy of Engineering.

(Proceedings Volume in Press)

2/11/72 Letter request

I have usually taken opportunities such as this Conference to emphasise to my listeners the importance of coming to terms with the realities of the problems of blind mobility and of providing solutions which had a chance of being accepted and implemented soon on a fairly wide scale. For once I have decided to forgo the selfimposed rigours of this particular approach, partly because I am sure most the present audience are only too aware of the realities of the situation and partly because the approach which I favour has just been widely circulated and is available to anyone interested. (Leonard 1969). Most of what I want to talk about will therefore be in the nature of speculation rather than based on hard evidence, and indeed, for the core of my argument I shall have very little experimental results at all.

Let me begin, however, with a brief visit to the real-world. Slide 1 shows a list of attributes of the blind population which in that real world we have to take account of: onset and degree of blindness; age and sex; additional impairments and socio-economic status; motivation, intelligence, and personality. Thus, 'the blind man' is an almost untennable concept unless we do specify more clearly. One consequence of this position is that there is a very considerable need for a variety of solutions to meet individual requirements and needs. Another consequence and one which is equally important, is that we must be very careful not to become overdetermined by the opinions expressed by a single blind user, however good and competent he may be. For as often as not he is most likely to speak from his own exerience only. It is clearly up to us to establish the extent to which one would be justified to generalise from his experience to that of other blind users.

Slide 1 - here

Slide 2 shows at least one dimension of the definition of needs: the range of attainment in terms of the spheres of mobility-activity. At one end is the chairbound individual and at the other the sighted pedestrian. In one sense the answer to our question is quite simple: our blind man needs to see. But as far as the realities of the situation are concerned, the case for social spending, (where the blind are in competition with other disabled populations), can not be sustained beyond the limit of self-dependent, safe, and reliable travel in familiar areas up to and including the route to work.

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If our solutions could do that for most of the population at risk, we could be very pleased. It is reassuring to note that the range of solutions presently available: short cane, long cane, guide dog and sonic aid, are well on the way towards achieving this aim: in the foreseable future it is my guess that the only practicable steps will be in the direction of improved and more widely available training schemes for those existing devices. If, beyond the point at which travel along familiar routes up to and including travel to the place of work is achieved, it is possible to provide the capability of travel in unfamiliar areas, this a bonus as far as the real world is concerned. Desirable undoubtedly; a need, more questionably. I am therefore very glad to have this opportunity to associate myself very closely with a good many of the points made by Bill Curtis in his paper on this topic yesterday.

Slide 2 - here

Slide 3 shows in more detail what we expect qualitavely from the best of our existing travellers, regardless of aid employed. I have elsewhere described it as representing the core of sighted mobility: those who at present meet all those criteria to the full are doing so by virtue of either lengthy training or a good deal of initially painful experience; their vocabulary of routes is fairly restricted; and as far as our evidence goes, they pay the price of heartrates higher than when walking about guided. There will soon be a further index, that which relates to the smoothness of progress, but so far we do not have enough data. Here let it suffice to say that any new device or training method will have to equal or surpass these criteria. This, together with the cost of training, and of devices form a goodish part of any cost-effectiveness equation.

Slide 3 - here

Slide 4 lists the categories of information supplied by vision for the purpose of sighted mobility. Object detection, orientation, posture, and terrain changes are the four large categories, and again it is good to realise the extent to which existing mobility aids and training methods are providing non-visual equivalents of categories. But of course, vision does so 'naturally' for man these

is a visual animal; and vision does so with vastly greater richness; and vision does so over a much wider range.

To illustrate this let me just insert an anecdote from the early days of my work when I spent a good bit of time watching blind travellers. I would do this for about ten consecutive working days on their own familiar route to and from work. After one such stint, I discussed the experience with this particular blind man and pointed out some ten or so instances where on most mornings he got himself into more or less dangerous situations - dangerous to himself or others. He could have avoided these by making use of quite simple landmarks. He accepted two of my suggestions but for the rest: "Dear Dr. Leonard, I have got better things to think about on my way to work than think about finding your bloody landmarks." That in a manner of speaking puts it in a nutshell, and I have got that engraved somewhere on my desk.

Slide 4 - here

Let me digress here very briefly: there is an immediate need for more work on the postural side, particularly for the congenitally blind. Here the problem is one of providing adequate feedback, detailed, augmented, non-visual feedback for actions which are predominantly under kinasthetic control. The pioneer work of Kooyman, Doris Tooze, and Cratty, is of great value here, but it must be extended.

Slide 5 looks at the need problem another way round. Given that the traveller describes or follows a path between any two points, what kind of information about this path is required? On the slide I have put down simply two headings: clear path and environment sensing. I leave it to you whether you prefer to think about this as two distinct categories or two dimensions. But the point is really quite simple: does the traveller need mainly clear-path information or does he also need information about the nature of the boundaries of that path or any object within that path? It is my impression that most of the blind people I have observed so far are interested primarily in clear-path information and only very incidentally in environment sensing. To become concrete: my impression is that most travellers want to know at most that there is a tall round object in their path, but they are not concerned to distinguish between tree, lamp-post, traffic-sign, etc.,: most blind travellers are primarily interested to know that they are maintaining their desired path, but are not particularly interested to know most

of the time whether they have passed trees, lamp-posts, parked cars, or bus-shelters. They may want to do so at certain points of a route and undoubtedly there are some travellers who do like to know a lot about the environment they are travelling through. Equally obviously, what blind people say at any moment in time is conditioned very much by the ease with which they can obtain more detailed information. Thus, an improved method of gathering and displaying information might well change the stated needs of blind people. One of the disincentives to independent blind travel at the moment is that it is confoundely lonely and boring - if easily handled environment sensing could overcome that then the position I have stated above might well change.

Slide 5 - here

Slide 6 takes us a little bit further into the theoretical realm. This is a highly schematic block/flow diagram of the systems involved in natural as well as aided mobility. Everything solid is natural, while everything dotted is aided. On the left then we have the environment, which feeds into the Sensory Surfaces, which feed into the Projection Areas. The next box we'll just leave with a question mark because that's as good a symbol for it as any other. From here we go into a box labelled Mobility Control where all action required for mobility is initiated. This feeds mainly back into the environment of course, but there is a parallel line back to the Sensory Surfaces as well. The dotted or aided system starts with an Information Gathering box which is fed by the environment. It feeds into an Information Processor which in turn feeds into the Information Display. This feeds into the available Sensory Surfaces, or in the case of the implants into the Projection Area directly. In fact the scheme drawn out here applies to any kind of sensory aiding situation. One of the perpetual arguments is just how much processing needs to be done in the dotted system and how much can be left to the solid system. Let's just leave that slide up while I carry on the argument.

Slide 6 - here

If then we restrict our thinking for a moment to an adult blind person, otherwise fit, adventitiously blinded, round about

average intelligence, and wanting to be self-dependent in his mobility (where the latter is operationally defined in terms of the effort and the cost he and/or society are prepared to make available towards that aim) our problem is to present non-visually the information which is normally available through vision.

From here on out I propose to extend an argument which I have only sketched in briefly in another paper (Leonard 1969). On the one hand we know that if a sighted person is suddenly bereft of sight, e.g. by blindfolding him, he is to all intents and purposes totally incapacitated as far as effective mobility is concerned. This is the measure of the extent to which intact man depends upon vision for his mobility. On the other hand we also know that there are at least some congenitally blind people who manage to move about pretty well without any aids at all. The difference between their achievement and that of sighted mobility is a measure of the extent to which it is possible to achieve effective mobility by non-visual means. While so far I have not met any totally blind person who has been able to move about as well as a sighted person, those who come closest to those levels manage to do so almost certainly on very much less information than do the sighted. I therefore want to examine in more detail the concept of the minimal information required for effective mobility.

To start with, it seems reasonable to assume that we do not have to present all the information non-visually which is normally available through vision. We know, for instance, from observing people with very small amounts of residual vision (so little that it can often not be specified) that they have almost all the mobility characteristics of a sighted person. One of the most obvious limitations is in the realm of range, or better still in terms of overall coverage. Clearly, for the vast majority of the criteria of sighted mobility to be met we need neither the 100 meter range nor the visual angle of some fifty degrees or so of simultaneity.

It is also fairly certain that we do not need anything like the the normal degree of visual accuity for most purposes under consideration. For you have to have pretty high degrees of myopia before you become markedly helpless in the mobility field.

Finally, as an example of arriving at some idea of an irreducible minimum of information required, it seems reasonable to assume that we do not need all of that information all of the time - there could presumably be some economy by time-sampling and possibly by time sharing. We can certainly shut our eyes for seconds at a time without much apparent decrement as long as we have full vision. Just how much bandwidth is

required is a moot question at this time, but no doubt one could carry out experiments along the lines of Senders' subjects who drove along certain stretches of highways with only intermittent vision permitted. There are some quite serious methodological problems about the equivalent experiments for our purposes (for instance, it is known that there is a tremendous learning effect with residual vision cases), but no doubt these problems could be overcome.

Let us assume that in one way or another we have arrived at specifiable minima of information and let us assume further that we have encountered only non-academic problems, such as cost, in devising methods of gathering that information. We now have to display it. So here we are entering the area of coding, but more importantly of the relationship between displays and controls. The time has come to talk about compatibility. Now in ordinary human engineering parlance what we we mean by that is the extent to which changes in the dispaly state can be translated into appropriate action more or less easily. When it is easy we talk about high compatibility, and when it is difficult we talk about low compatibility. We are not particularly concerned in the first instance whether hight compatibility is the result of natural inclination or of learning: compatibility is a purely operationally defined concept and usually it is measured by comparing sets of display-control relationships and observing speed, accuracy, and rate of acquisition for each one.

The point about compatibility is of course that it refers to a relationship between display and control, and that it is meaningless to talk in terms of either displays or controls being compatible by themselves. Within a given display, display states will have to be discriminable from each other, and within a given control there will have to be sensitivity: but the overall problem is how to achieve the best transfer of information from the environment to the operator so that appropriate action, whatever that may be, can be carried out.

When we come to consider the problem of mobility we are dealing with a fixed display-control relationship in the intact organism: the display is provided primarily by vision and the control are the various movements what have to be carried out in order to move from A to B and in order to maintain our orientation and our posture. In this sense, then vision provides the natural display for mobility, and anything nonvisual has to be considered as un-natural and as requiring a measure of learning before it can begin to approach to efficiency of vision. We can go further and say that the mediating processes between display and control is natural and highly developed in intact man, just as it would appear to be natural for some species of bats to process auditory information for the purposes

of mobility.

Let me just quickly go over the crucial properties of vision in man: it is a parallel-processing system covering a very wide segment of the environment relative to man's size and relative to a pedestrian's speed. It is conventional to speak of the richness of visual information and of its accuity: I would want to stress the fact that it provides us with a constantly present and effectively stable frame of reference which includes a surprising amount of our own body as an anchor. In general we tend to think of vision as presenting considerable amounts of information simultaneously, while the non-visual sensesoperate primarily sequentially. Thus the problems in vision tend to be those of analysis, while those of the non-visual senses tend to be those of synthesis.

Given then, that the control element of the mobility taks remains constant let us consider first of all existing non-visual displays which are at least 'good' in their own right (if you will let met get away with that for the moment) and which are known to produce at least a measure of compatibility in the mobility situation.

Tactually, there is in the first instance the whole of the body surface and more particularly the extremities. Contact with the environment is a farily direct signal in that system, but it is of course very limited in range and therefore some extension is required. The display provided through canes and the handles of guide-dogs are evidently 'good' and can achieve pretty high levels of compatibility with the control system. Their use clearly increase the limits and speeds of progress, once their manipulation has been learned. In this context it is of some interest to note that one of the initial problems in learning how to benefit from the long cane is not so much to recognise that the tip has made contact with an object, but to know where the tip is in relation to one's body.

On the auditory side we have known for some time about the role of the display properties entailed in so-called facial vision, and we have learned a lot more about the 'goodness' of active environmental noise patterns in recent years. With regard to the display properties involved in 'facial vision' a careful study of the work of Ivor Kohler might clearly be in order when we come to consider the position of artificial auditory displays.

The display of the Sonic Aid provides a rather splendid example of the relationship between the properties of displays

and any resulting compatibility. Consider in the first case texture information presented by the Sonic Aid. This is almost a "natural;" most individuals I have tested could tell a hard from a soft surface on first exposure. With the aid fixed and a good reflector moving at right angles to the transducers, it is not very hard for most subjects to tell a near from a far signal; and with not very much learning they can make fairly accurate verbal judgements which relate perceived pitch to distance. With the reflector less good, or obliquely to the transducers we being to run into some difficulties even in a judgement situation. Matters being to get distinctly more difficult in terms of learning times when the display state has to be related to action, rather than described verbally. But much can be learned, and thanks to the work of Sharpe (1969) we do now have a much better idea of how much learning may be required for what kind of achievments.

What the Sonic Aid story illustrates extremely well is that a display may be jolly 'good' when it is measured in terms of one set of criteria, and not quite so good when measured by another set: there may well be all sorts of other artificial displays which may be 'good' in the sense that one can obtain efficient verbal responding to them when they are tested in the laboratory, but which may not have very high compatibility with the control system involved in mobility.

This is of course simply restating what I said earlier on about the definition or specification of compatibility, i.e. that it refers to the examination of the relationships between sets of displays and sets of controls and the some of these relationships might be better than others. There is thus a sense in which it is right to say that certain aspects of the Sonic Aid's display are highly compatible when studied in relation to a verbal output but that they produce much less compatibility when studied in relation to a mobility output. But there is of course one non-visual display which everybody handles every day and knows how to deal with: speech! How useful could speech be as the output of a mobility device?

Now just before everybody combines to pick up objects detected in the environment and to hurl these at me, let me duck and assert that I think we should consider this quite seriously for a moment. At the very least as a tool in an intellectual exercise, but also possibly as a tool in experimentation. Let me just remind you that we are here and now in an era in which pretty substantial claims are being made for both vision substitutes and visual protheses. In both these cases the information gathering side of the shop is a t.v. camera and in both a least a measure of processing has to be carried out before the gathered information is displayed. And, as far as one can tell at present, the problems is going to be a pretty hefty one

when one moves from degraded to real-life situations. Let us assume that a speech output from a t.v. camera might be technically feasable, why not? Let us then consider for a moment the kind of situations in which speech is already used in mobility-like situations. The most dramatic one is of course the 'talking-down' of aircraft. In these situations both the controller and the pilot make use of a language system specially acquired for the purpose, i.e. the major problem was one of software. Less dramatic, but perhaps more to the point is the use we make of speech in giving overall directions for all kinds of users, and more detailed directions about some aspects of blind mobility when as a sighted person we guide a blind client or subject - as the case may be.

The least the idea of using speech may enable us to do is to sort out the different levels of commands which are required for mobility purposes. If we go back to slide 4 for a moment we will see that we should have no trouble at all in using speech for object detection - whether we restrict ourselves to saying that there is an object in the desired path or go into details about describing this object. We could use speech to ensure that our subject avoided and object or that he was aware of the nature of that object. Similarly we would have little difficulty about orientation, both far and near. Indeed, speech is already used to provide far-orientation information. And it would not be hard to instruct a subject to stay in mid-pavement, though it might be a bit harder to ensure straight travel. And while there would be no problem about informing out subject about relatively large changes in terrain, there might be very severe problems about the smaller unevenesses of the terrain. Posture would be the most difficult and would require some additional fairly simple feedback devices, at least intermittently.

Thus, on the face of it, speech could be used quite easily for all those actions fo· which there is already a language system such as "left-hand down a bit," "slow down", and so on. And it might well be that for quite a number of other situations one could develop additonal vocabularies.

Experimentally, then, the problem is to device a simple mock-up and to study the extent to which speech can be used to guide a blind or blindfolded subject through various situations so that he performs at least as well as under any of the existing systems. This might very well provide us with a tool in our study of estimating the type and amount of information required and the rate at which it would have to be supplied for different situations. In practice I suspect that we would not be able to do this with any subjects until they would have acquired at least a modicum of pre-cane skills so that they would no longer be afraid of walking about without the use of their eyes. This

could very well prove to be a more useful approach than that which I have suggested in the past, i.e. the study of the role of residual vision or of restricted vision referred to earlier on.

I hope to be able to present some evidence about the use of speech and to discuss some of the difficulties encountered during this or the next session. I suspect that once a subject had acquired full trust in his 'controller' he would be able to rely on speech for all but the fine terrain structure information, for which he might still want a long cane. For it is here that the long cane comes up trumps since it speaks 'body-language' as far as these small unevenesses are concerned.

I suspect that the same constraint will apply to almost all other artificial systems. For if speech is not on for one reason or another, my guess is that the next most meaningful display will be some form of body-tactual such as the group atSmith-Kettlewell are working with. Now as I understand the philosophy of both that group and the people working on implants it is that the information gathering system should look at the raw environment and that the information obtained should be displayed with as little processing as possible in 'raw terms.' If we we could just have slide 6 back again and stick with vision substitute rather than with implant I think I know what I would go for by way of a body-tactual display if we were to be asked to build upon the work at Smith-Kettlewell and were given the resources to do so. I would aim at having a very simple display representing the clear-path configuration no more than 10 - 15 feet ahead and covering not much more than two or three shoulderwidth in the up-down dimensions. Such a configuration would on most occasions in the U.K. at any rate include a representation of the shoreline, because with us there are usually walls or fences, and this would help the user to maintain moment-to-moment orientation without the need to have relative motion between himself and the environment.

To achieve such a body-tactual display one might have to have quite a lot of processing between the information gathering device and the display - and no doubt it will be argued that this processing had best be left to the user's central nervous system. I have my doubts about that one at least as far as the majority of potential users is concerned. But in any case I would put forward the plea that in the first instances in which the new devices are to be employed in a mobility settling the range involved should relatively short, and the amount of detail displayed relatively little when compared with the range and detail available via vision. As far as one can tell at the

moment, for most practical purposes the range provided by the long cane seems to be sufficient while the somewhat longer range of the existing sonic aid may well be too much. (It is of course quite possible that with a better display, and particularly with one which could mimick vision in its simultaneity, the user could benefit from more range and volume of explored space). What I am suggesting here is that one should begin relatively simply.

Short of being able to go directly into the visual cortex, speech and body tactual displays seem to me the only really viable artificial displays for other than experimental purposes as far as the bulk of the blind population is concerned. I may change my mind in the light of work now being undertaken by Dr. Armstrong of my Unit on the use of various auditory displays grafted onto the output from Sonic Aids. But everything we have seen and done so far suggests that most existing or contemplated forms of artificial display are not sufficiently compatible for Mobility Control, the gain for the user is not sufficient to make him want to put forward the effort required to improve the compatibility. It is worth bearing in mind that so far the only aid to mobility which does not show a sizeable post-training wastage is the guide-dog. Long-cane/orientation training, particularly when provided without selection or on a shorestring budget, appears to have sizable wastage. It is too early to say what the situation will be like for the hand-held Sonic Aid since so far we still have to persuade the powers that be to provide appropriate training facilities. If we simply take the number of people supplied with an Aid in the U.K. and with some form of training then the wastage is considerably higher than that for long-cane/orientation.

I have very nearly done. Way back I said that I would restrict myself to an adult blinded person, adventitiously blinded, round about average intelligence, and wanting to be self-dependent in his mobility. By now you will see the reason for most of these specifications, and only the exclusion of the congenitally blinded person must be accounted for. I excluded the congenitally blinded from this argument solely on the grounds that by definition they first require to be provided with a great deal of background information about their own body and about the nature of the world around them before you can start providing them with any mobility device - this at any rate has been our experience so far. Certainly, most of those I have met, needed to know a lot for instance about hand-positioning before they could benefit from a cane or sonic aid; and much the same applied to the use of the headmounted sonic aid. Certainly up to this time in the U.K. the majority of the con-

genitally blind have relatively little generalised knowledge which would enable them to recognise common configurations described either by speech or by a spatial tactual display.

Since I have already gone out on a limb in this paper way beyond the point to which I am accustomed to doing this, let me give you my view of the present position in work on blind mobility. By now, well above the horizon, are solutions which are certainly expensive, equally certainly very attractive, and just a shade less certainly feasable. I refer here to more than just the concepts of vision substitute and implants. At the same time there are with us a number of existing and viable solutions the cost-effectiveness of which it is not impossible to assess. By now, most blind users and those providing services for them, will want to know about the cost-effectiveness of any new interim solutions which might be proposed. They will want to know the cost in terms of money, time, and effort in relation to demonstrable or likely gains.

Perhaps one might have a try at conceptualising this a little bit better. In the last slide I am having a shot at this by showing a three-dimensional co-ordinate system with effort, gain, and risk as the three axes. (Note that this is as close as I propose to get to the problems of acceptability which were discussed in other sessions.) Effort might be measured in terms of actual cost, training time, ease of handling, etc. Gain might be expressed in terms of the extent, quality, and ease of travelling as discussed earlier on; and risk in terms of likelihood of incurring accidents above a stated severity or part of body left unprotected. Obviously one wants to try to minimise on effort and risk, and maximise on gain. What I have been saying in the last two paragraphs can now be restated. Existing methods enable quite reasonable gains to be attained at evidently acceptable levels of risk, but at pretty considerable effort. I doubt whether users on the whole would be prepared to accept an increase along the effort dimension unless there could be very significant increases along the gain dimension.

Slide 7 - about here

Note also that this kind of scheme may help one to categorise individual users: for each one can in theory be located somewhere within that effort-gain-risk cube, and quite obviously they will not all be in the same location. For instance, some users appear to be much less worried about falling off a kerb

than about injuring their heads - while others are prepared to put in considerable effort in order to achieve the gain provided by a guide-dog. As a result of a systematic comparison of different mobility aids we in this Unit are beginning to build up an interesting collection of materials on this topic.

As far as the work of my own Unit is concerned we shall continue to put most of our effort towards improving the cost-effectiveness of existing methods - and that obviously includes measuring costs and gains. We will also try to do some denting of the frontiers but we shall try to do so in a small-step, realistic kind of way. To those who have the material and financial resources to go for the more exciting solutions we wish luck and success in their work, and hope that they will progress at such a rate that our own type of work will become unnecessary.

Let me sum up. I started by dealing with the properties of our potential user population and its needs. From there I went on to show the extent to which existing methods of aiding mobility are able to meet these needs. This led to an examination of the role of vision in sighted mobility and the presentation of the information flow for sighted and aided mobility. I then sought to develop the concept of minimal information required for mobility and the means available to display that information to the user. This led to a discussion of the concept of compatibility between displays and controls. I went on to suggest the use of speech and body-tactual displays as being the only viable artificial displays and spoke briefly about the cost-effectiveness of existing and suggested methods of aiding mobility.

Let me end by restating the concept of 'minimal information' with a caution: it is just possible that the difference between visual achievements in mobility and non-visual ones may come down to having just a little more than minimal information: it could be that sighted mobility is as good as it is because there would appear to be an awful lot of redundancy.

Postcript: Since writing this I have had a quick chance to try out the spectacles and Dr. Armstrong and I have visited both Smith-Kettlewell and Stanford Research Institute. The only substantial change I would want to make to what I said earlier on in this paper is to include Jim Bliss's types of displays in my comments on the need to display the 'clear-path' configuration to the traveller. Apart from that I stick by every word of the precirculated paper.

References

Leonard, J.A.	1969	Account of a Research Programme into Blind Mobility. Proc. NATO ASI, (to appear in print)
Sharpe, R.	1969	The Evaluation of the St. Dunstan's Manual of Instruction for the Kay Sonic Aid. B.M.R.U., Dept. of Psychology University of Nottingham.
White, B.J. et al	1970	Seeing with the skin. Perception and Psychophics, 7, 23-27.

N.B.

Copies of the first two papers can be obtained from the Blind Mobility Research Unit, Department of Psychology, University of Nottingham, England

Personal Variables

Age

Sex

Onset of Blindess

Degree of Blindness

Motivation - Mobility Needs

Additional Impairment

"Intelligence"

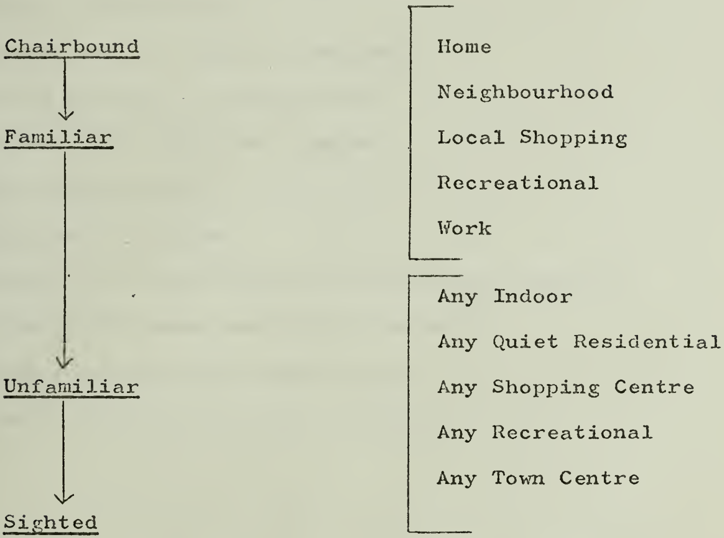
"Personality"

Socio-economic status.

Acceptance of Risks

Slide 1.

Mobility Needs in Terms of Areas of Activity



Chairbound

Familiar

Unfamiliar

Sighted

Home
Neighbourhood
Local Shopping
Recreational
Work

Any Indoor
Any Quiet Residential
Any Shopping Centre
Any Recreational
Any Town Centre

Traveller can:

Move through familiar environment

Move through unfamiliar environment

Move at speeds equal to sighted

Travel straight line midpavement

Detect end of blocks

Detect and anticipate downkersb

Cross straight or correct veer

Detect and anticipate upkerbs

Make indentations

Pick up true paths

Detect obstacles/landmarks auditorily-tactually

Sense environment auditorily-tactually

Handle effectively sighted help

Handle effectively public transport

Slide 3. Criteria for general Levels of Mobility

Vision ordinarily provides information for:

- Object Detection
  - Obstacles
  - Landmarks
- Orientation
  - Near
  - Far
- Terrain Changes
- Posture

This information is generally capable of being

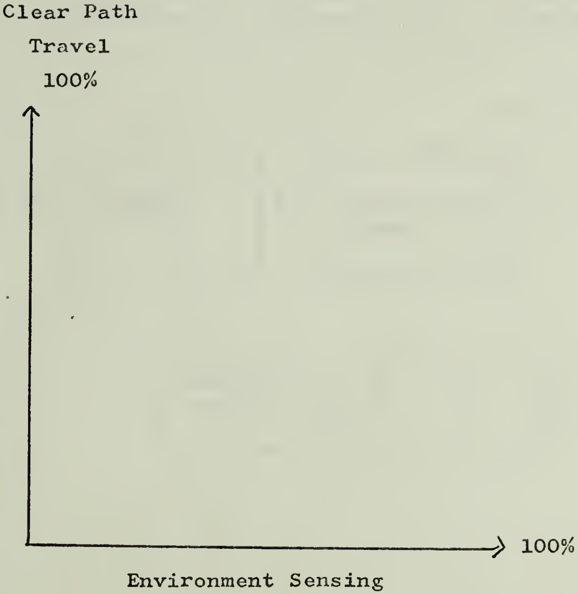
a) monitored at low levels of awareness

b) acquired well ahead of time action is required i.e. it is anticipatory.

The Information provided by an aid to blind mobility should have the same capabilities.

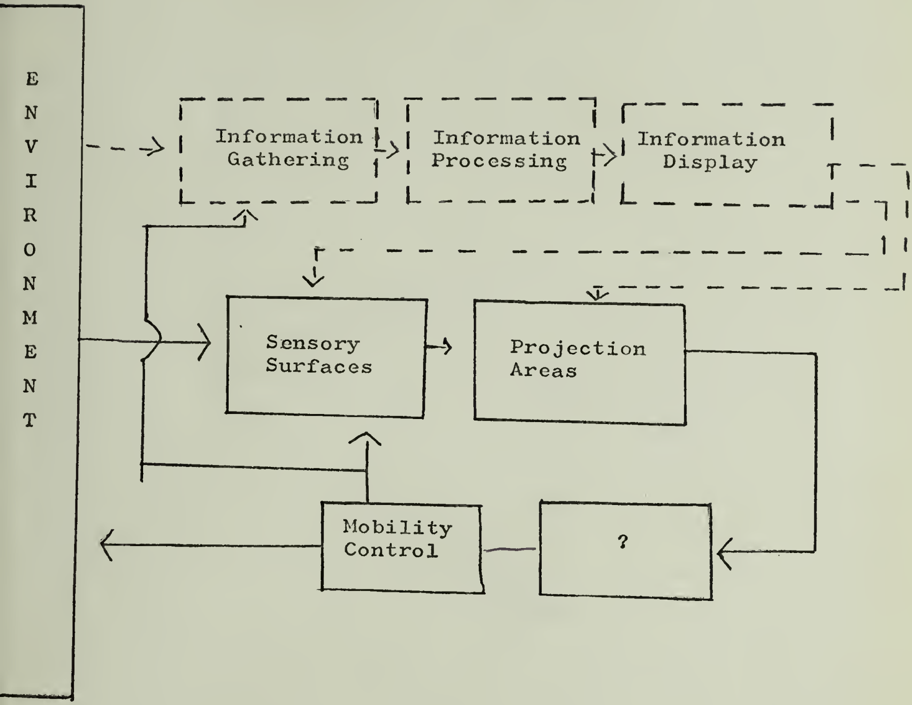
Slide 4. - The Roles of Vision in Mobility.

Mobility Needs in
Terms of Required Information

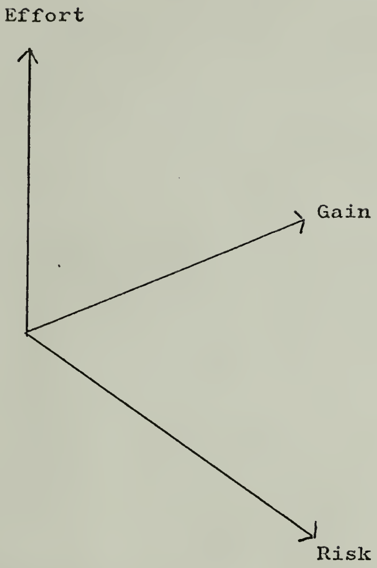


Most users needs are satisfied by maximising on C.P.T. with a minimum of E.S. for intermittent orientation. Some users might have no C.P.T. requirement but have great intellectual/emotional need for E.P.

Slide 5.


E N V I R O N M E N T
Information Gathering
Information Processing
Information Display
Sensory Surfaces
Projection Areas
Mobility Control
?

Slide 6.



Slide 7. - Effort, gain, and risk as dimensions in the choice of mobility aids/training.